

The WTC Environmental Health Program “Survivor program”

Joan Reibman, MD

Associate Professor of Medicine and Environmental
Medicine

New York University School of Medicine

Bellevue Hospital

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Bellevue Hospital Center
Elmhurst Hospital Center
Gouverneur Healthcare Services



nyc.gov/hhc

WTC destruction as an environmental disaster

- Community at risk for WTC dust/fume exposure

- 60,000 residents south of Canal Street alone
- 300,000 area workers/office workers, commuters, teachers
- 15,000 students



- Disaster exposure science and a community at risk
- Background history of the WTC EHC program
- Clinical findings of WTC EHC program
- Unanswered questions

Environmental human exposure science

- Basic tenets of human exposure science:
 - Does an exposure factor have a potential health risk (biologic plausibility)
 - Exposure assessment
 - Human disease assessment
 - Estimate dose-response relationships

Environmental disaster exposure science

- Systems in disarray
- Politics and economics complicate questions of potential health risk
- Exposure assessment may not be feasible
- Disease assessment systems not available

Did WTC dust/fume exposure pose a health risk to the community

- Risk denied by EPA
- Residents told to damp mop
- Local workers returned to work 7 days after event
- Concept of potential health risk to surrounding community only accepted after delay

Exposure assessment – toxic agents?



- 1.2 million tons of building materials
- 90% of settled particles >10 μ m diameter
- 11,000 tons of particles < 2.5 μ m diameter

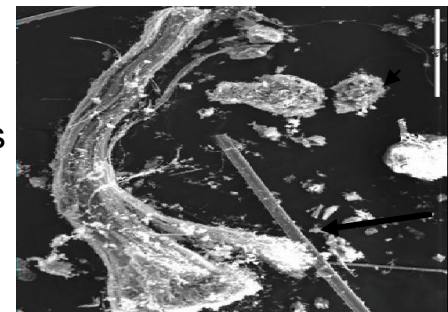
Characteristics of settled WTC dust

- Alkaline (pH9-11)
- Construction materials
 - Cement
 - Concrete
 - Wallboard
- Particulate matter
 - Calcium sulfate (gypsum)
 - Calcium carbonate
 - Crystalline silica
- Fibers
 - Fibrous glass
 - Gypsum fibers
 - Chrysotile asbestos

Banauch et al. Curr. Opinion Pulm Med 2005, 11:160-168

USGS Environmental Studies of WTC

asbestos



concrete

glass fiber

Chemical constituents of WTC dusts

- Combustion of jet fuel
- Combustion products of plastics, metals, woods, insulation, fluorescent lights, computer and video monitors
- Organic pollutants
 - Polycyclic aromatic hydrocarbons
- Hydrocarbons
 - Napthalene
 - Polychlorinated biphenyls (PCBs)
 - Dioxins
 - Benzene
- Heavy metals
 - Mercury
 - Lead

Exposure assessment for community members

- Complicated by variety of exposure possibilities
- Variable amount of time in area (there on 9/11, evacuated or not, returned episodically to clean)
- No studies done immediately after event to assess exposure
- Recall

Acute exposures - Dust cloud(s)



Debris before buildings collapsed

Multiple dust clouds

Extensive dust in afternoon after buildings collapsed

Chronic exposures - Outdoor dust exposures
Area workers returned to work on September 17, 2001



Chronic exposures - Indoor dust exposures



- Dust settled inside buildings/ventilation systems
- Dust resuspended from incompletely cleaned ventilation systems



Indoor dust exposures



- Few residents evacuated
- Chemical composition similar to outdoor



Gases and fumes

- Fires burned through December 2001

Structure of composite exposure scales generated by principal components analysis of DOHMH WTC Registry study

	Component Variables	Composite scale
Acute	Personal appearance after thickest part of cloud Visibility in thickest part of cloud Time first caught, relative to WTC collapses	Dust cloud - Density
	Duration of time in dust cloud Prop.of time in thickest part of cloud	Dust cloud-Time
Chronic	Extent of dust coverage at home or workplace Depth of thickest dust layer at home or workplace Proportion of home or workplace most affected	Dust - Home/Workplace
	Smelled smoke inside, outside, both Duration of time during which smelled smoke	Smoke - Home/Workplace
	Time at home or workplace Month first at home or workplace after 9/11	Time - Home/Workplace
	Participated in cleaning of home or workplace Number of items cleaned by subject* Time spent cleaning home or workplace	Involvement in cleaning - Home/Workplace

Maslow *et al.* Chronic and acute exposures to the WTC disaster and lower respiratory symptoms”
area residents and workers, Am J Pub Health in press 2011

Disease assessment in the community

- October 11, 2001 – Pace University Community Forum
- Academic-community coalitions
 - FDNY
 - Organized labor/Occupational clinics/local politicians
 - WTC Workers Medical Screening/Monitoring/Treatment program
 - Community

WTC Residents Respiratory Health Study



- Collaborative effort of NYU, New York State Department of Health and local community
- Funded by CDC and NIH(NIEHS)
- Cross-sectional study of control and exposed population designed, implemented and completed 16 months after 9/11/01
- Responses analyzed from 2,812 individuals

Persistent^b new-onset respiratory symptoms in “previously normal” residents

	Exposed (n=2410)	Control (n=271)	Crude Incidence ratio (95% CI)*
Cough without cold, %	16.0	4.0	3.99 (2.15-7.38)*
Daytime SOB, %	10.6	3.6	2.94 (1.53-5.66)*
Wheeze, %	10.5	1.6	6.50 (2.44-17.33)*
AM chest tightness, %	8.4	1.6	5.21 (1.95-13.91)*
SOB after exercise, %	7.4	1.7	4.45 (1.66-11.91)*
Night-time SOB, %	6.2	0.8	7.64 (1.90-30.70)*
Any of the above symptoms, %	26.4	7.5	3.53 (2.28-5.47)*

^bSymptom frequency ≥ 2 days per week in the past 4 weeks.

* Effect still statistically significant after adjusting for age, gender, education, smoking and race.

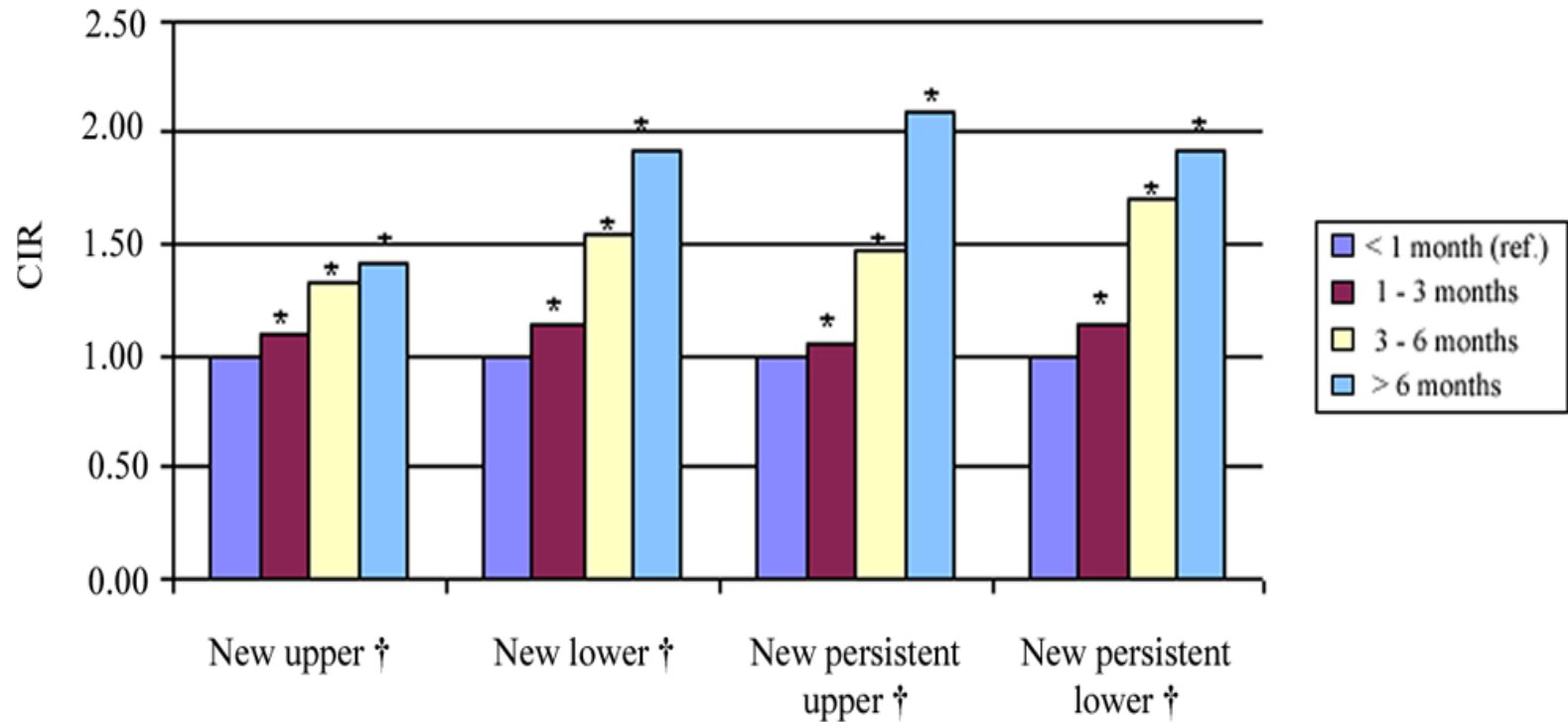
Increase in medical consultation and asthma medicine use in previously normal residents^a

	Exposed (n=2410)	Control (n=271)	Crude IR (95% CI)*
Unplanned Medical Visits (in the past 12 months)	13.7%	7.8%	1.77 (1.16-2.70)*
Fast Relief Med Use (in the past 4 weeks)	8.0%	3.3%	2.41 (1.25-4.65)*
Controller Med Use (in the past 4 weeks)	8.6%	3.7%	2.33 (1.25-4.34)*

^a No diagnosis of asthma, chronic obstructive pulmonary disease, chronic bronchitis, or other lung disease before 9/11/2001.

* Effect still statistically significant after adjusting for age, gender, education, and race.

New onset symptoms associated with persistence of dust or odors in home



NYC DOHMH WTC Health Registry

- Studies increased respiratory symptoms in subsequent DOHMH WTC Registry studies in individuals surveyed between 2003 – 2004

WTC Environmental Health Center

- Bellevue Hospital/NYULMC
 - 2002 community collaborative pilot program for treatment of residents/area workers in the Bellevue Hospital Asthma clinic
- WTC Environmental Health Center
 - 2005 American Red Cross Liberty Disaster Relief Fund
 - 2006 funding from City of New York
 - 2008 first Federal funding (CDC-NIOSH)

WTC Environmental Health Center

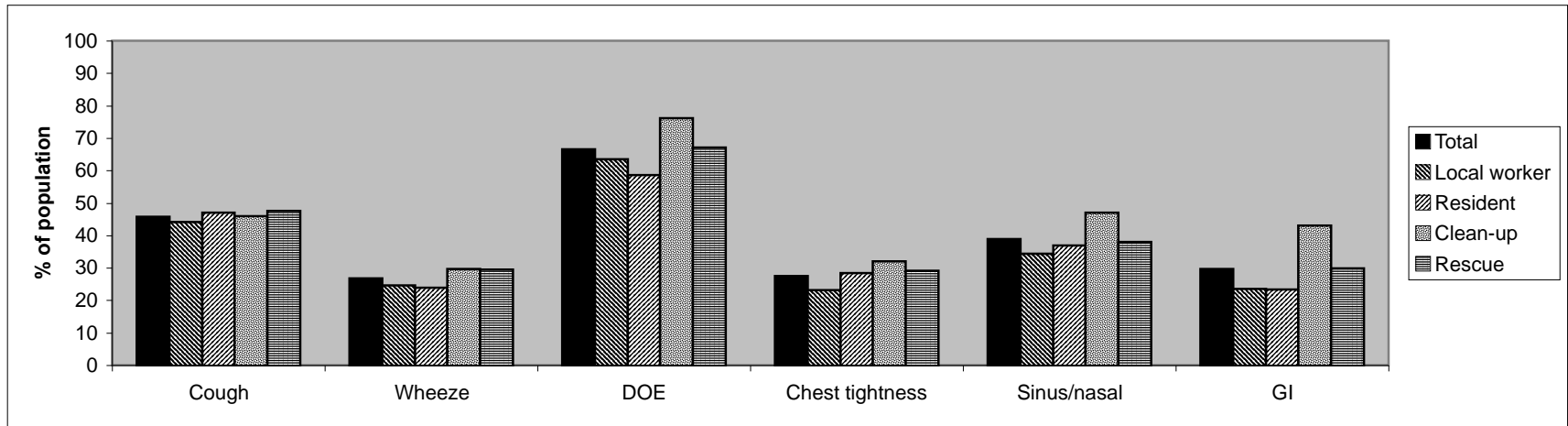
- Treatment program for individuals with presumed WTC-related illness
 - Had to have potential exposure (geographic boundaries)
 - Had to have symptom (initially physical, subsequently mental health or physical)
- Target populations: Non-rescue workers
 - residents
 - local workers
 - students
 - clean-up workers
- Multidisciplinary treatment program (medical, mental health, social services)
- Nearly 6,000 individuals enrolled between September 2005 to September 2011 for treatment

Characteristics of WTC EHC population enrolled 9/2005 – 5/2008 (N = 1898)

Characteristic	Total
Gender, N (%)	
Male	1005 (53)
Female	893 (47)
Age, mean \pm SD	48 \pm 12
Race, N (%)	
White	867 (46)
Black	318 (17)
Asian	217 (11)
Ethnicity, N (%)	
Hispanic	792 (42)
Dust cloud	740 (40)

Disease assessment – disease characteristics (symptoms)

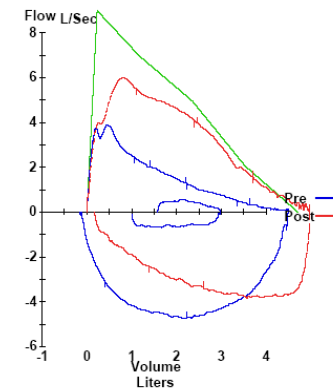
New onset persistent symptoms in previously normal
WTC EHC populations
(N = 1898)



Reibman *et al.* Characteristics of a residential and working community with diverse exposure to WTC dust, gas and fumes J Occup Env Med 2009

CASE MR

- 37 year old resident of Lower Manhattan (Beekman Street)
- Previously healthy (training for marathon), no history of childhood asthma/lifelong nonsmoker
- Not in dust cloud
- Stayed in apartment and cleaned dust-covered apartment
- Onset of shortness of breath and wheezing 6 months later
- Presented to WTC EHC in 2006 with persistent upper airway symptoms (nasal congestion, post nasal drip) and daily lower airway symptoms (shortness of breath, wheezing)
- Treated aggressively for asthma
- Continues to need therapy to control symptoms



Patterns of spirometry in WTC EHC patients with < 5 p-y tobacco use (N = 1109)

Spirometry pattern	Total N=1109
Normal	790 (71)
Obstructed ¹ , N (%)	67 (6)
Low FVC ² , N (%)	224 (20)
Obstructed and low FVC ³ , N (%)	28 (3)

How can we explain respiratory symptoms in population with normal lung function

- Hyperresponsiveness?
- Spirometry unable to detect small airway damage?
- Other reasons – cardiac, mental health?

Disease assessment – disease marker

Spirometry in firefighters before and after 9/11

	6-month exam % predicted (L)
FVC	90 (4.63)
FEV ₁	90 (3.88)
FEV ₁ /FVC	0.78

Spirometry in firefighters before and after 9/11

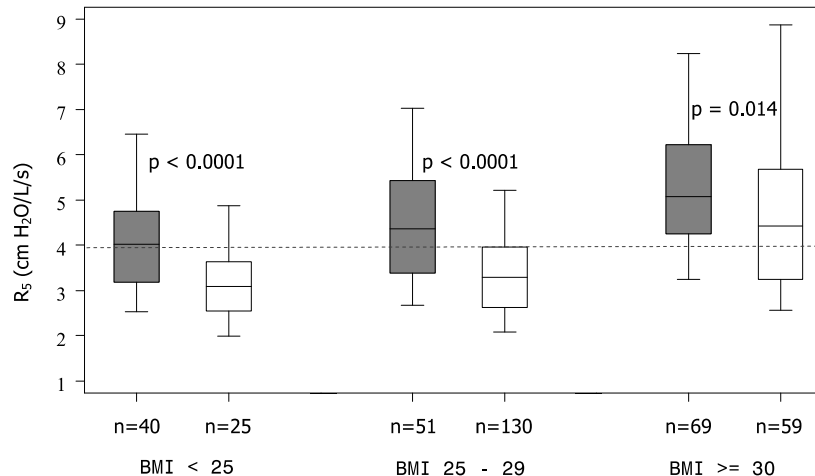
	Pre-WTC % predicted (L)	1-month exam % predicted (L)	6-month exam % predicted (L)
FVC	99 (4.94)	94 (4.70)	90 (4.63)
FEV ₁	103 (4.22)	96 (3.97)	90 (3.88)
FEV ₁ /FVC	0.86	0.79	0.78

- 6 year assessment: FDNY lost 360 - 390 ml/year of FEV₁ (normal loss of 31 ml each year)

World Trade Center Health Impacts on FDNY Rescue Workers: A 6 Year Assessment 9/01-9/07 Fire Department, City of NY 2007

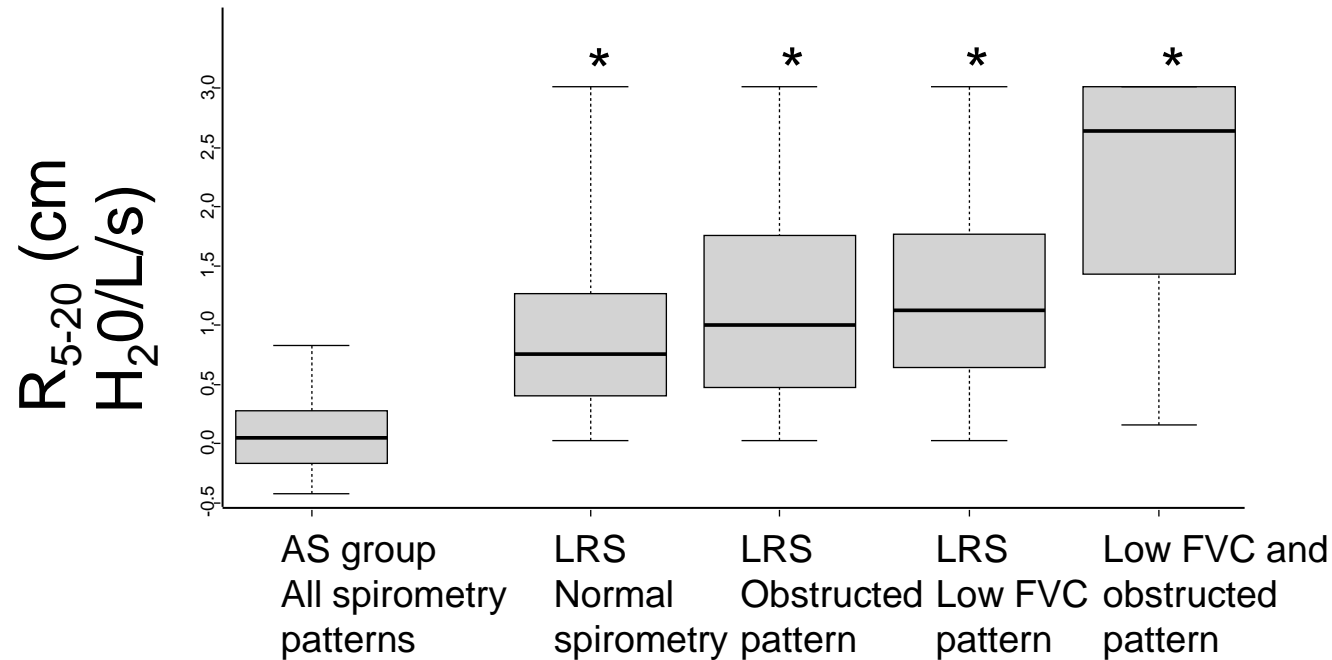
Impulse oscillometry as a non-invasive way to assess lung function, including distal airways

- IOS measures pressure waves applied externally to respiratory system at different oscillating frequencies
- Small studies of WTC patients suggested abnormalities in IOS (Oppenheimer et al. Chest 2007)
- Case-control study of DOHMH WTC Registry area residents and workers - elevated IOS measurements (R5, R5-20) associated with symptoms even in those with normal spirometry



Friedman *et al.* Case-control study of lung function in World Trade Center Health Registry area residents and workers Amer J Res Crit Care Med 2011

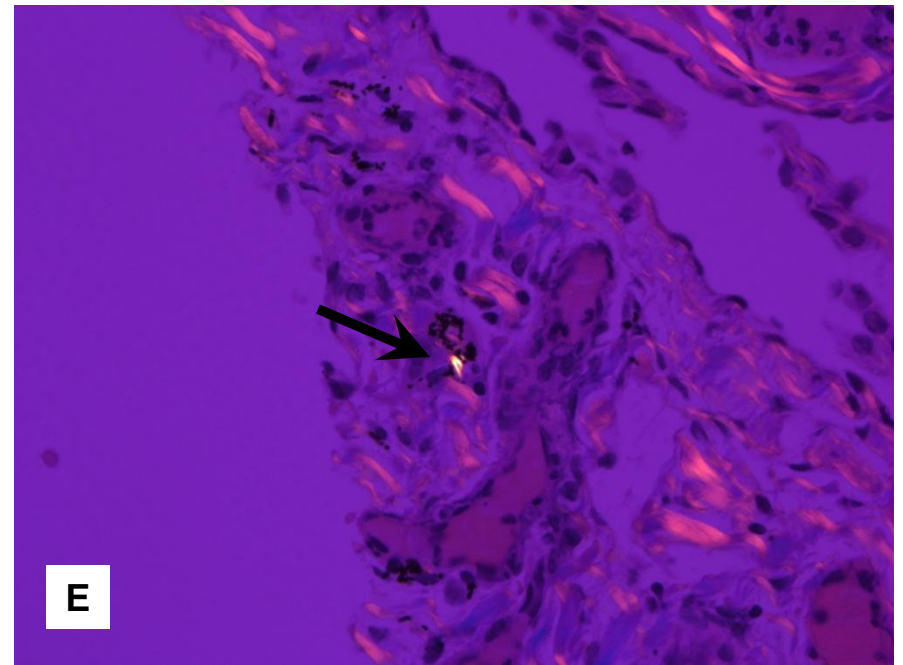
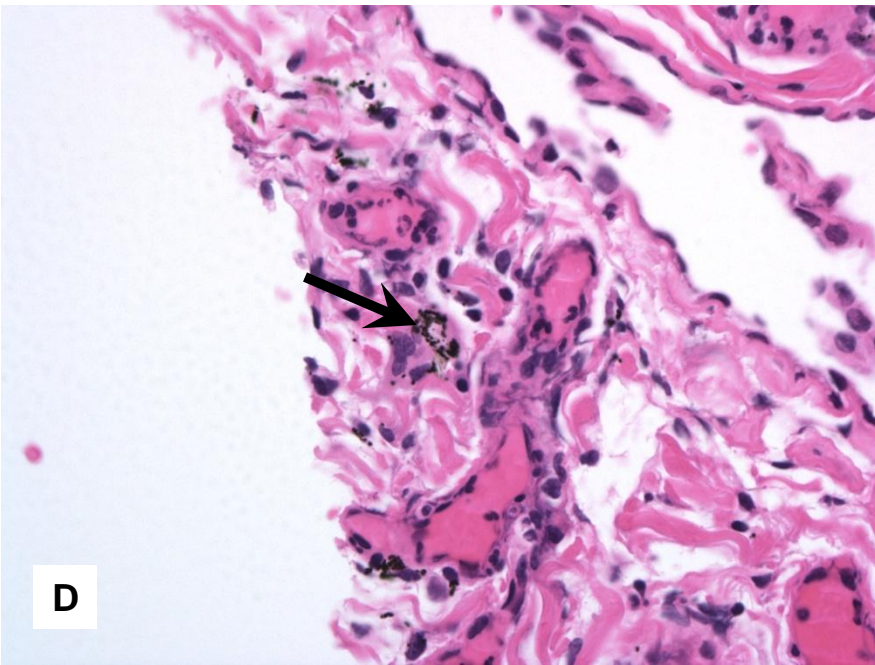
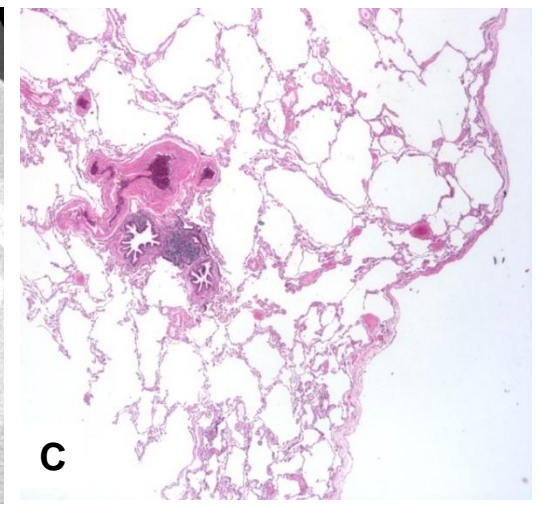
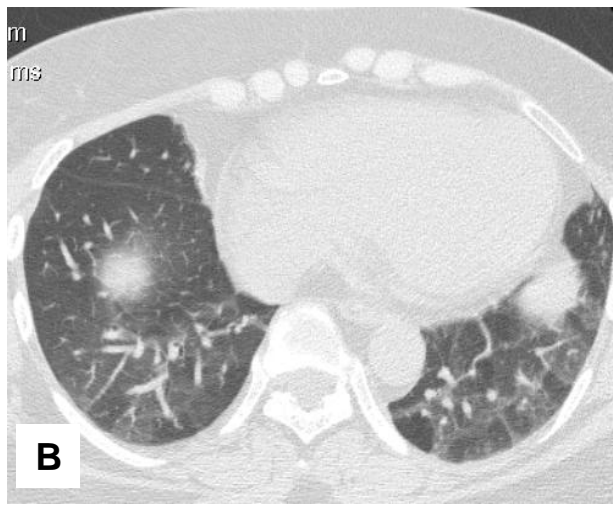
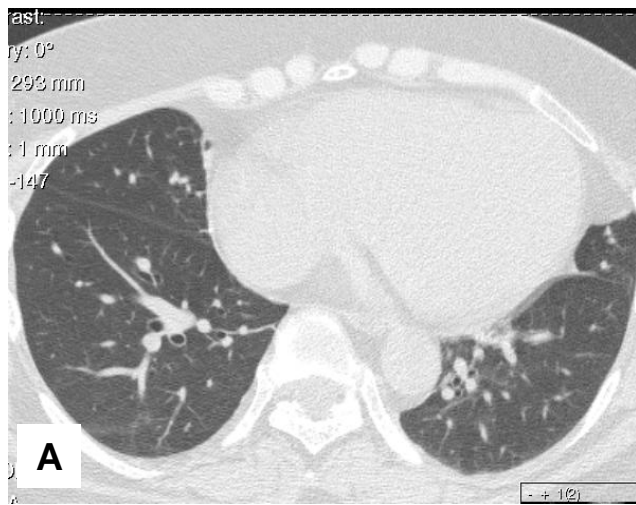
IOS (R5-20) was increased in WTC EHC patients compared to in asymptomatic control group



IOS increased with severity of symptom (wheeze)

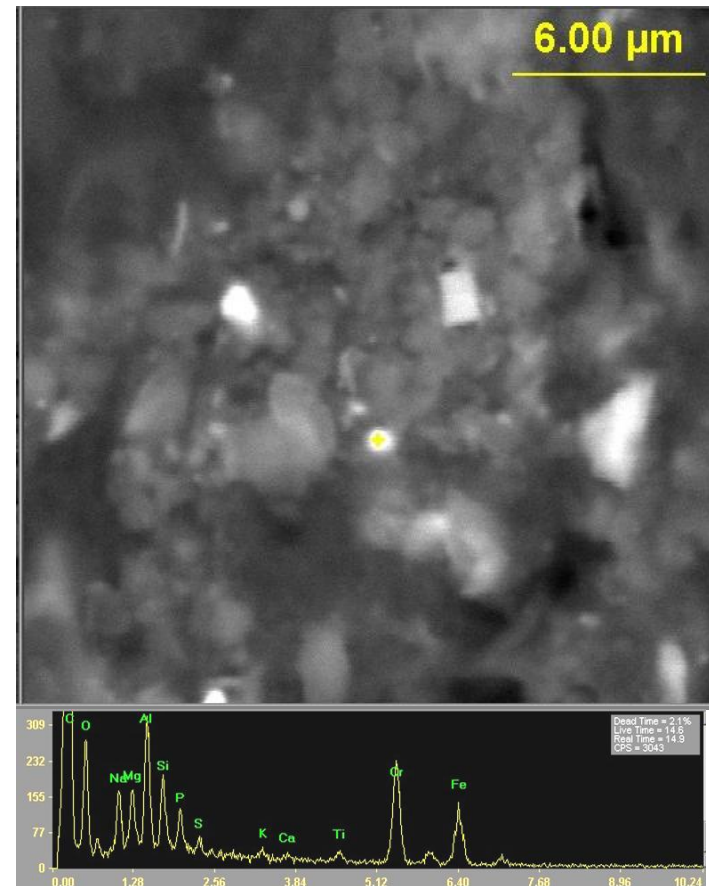
Pathologic findings in WTC EHC patients

- Case series of patients (N = 12) who underwent VATS (video assisted thoracoscopic surgery) for clinical indications
- Pathologic findings
 - patchy interstitial fibrosis
 - bronchiolitis and small airways abnormalities
 - emphysematous changes in all
 - intracellular birefringent particles under polarizing light microscopy



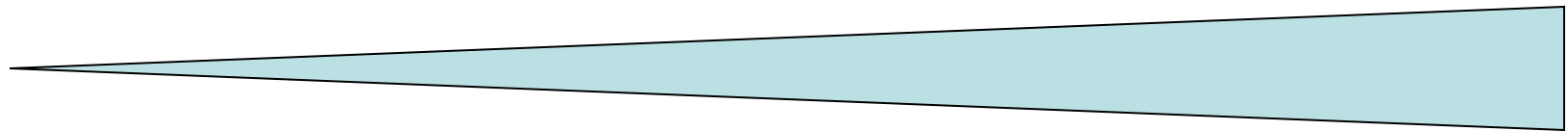
Particle analysis of lung biopsy specimens

- Scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM-EDS) performed on 5 samples
- Silica
- Aluminum silicate
- Titanium
- Talc
- Metals – steel, copper, chromium,



Disease heterogeneity in response to environmental exposure

Nasal/sinus Cough Irritant asthma Airway damage (bronchiectasis) Sarcoid ? Interstitial lung disease (NSIP, UIP, HP, ?)



Dose



Individual susceptibility

Atopy
Tobacco
Immune

Lung function over time in community members enrolled in WTC EHC (linear annual change ml/year)

	FVC				FEV ₁			
	Estimate ml/year	SE	95% CI	p-value	Estimate ml/year	SE	95% CI	p-value
Total	54	7	(41,67)	<0.0001	30	5	(19,40)	<0.0001
Spirometry pattern								
Normal	43	8	(28,58)	<0.0001	15	6	(3,27)	0.02
Low FVC	84	13	(58,110)	<0.0001	37	9	(18,56)	0.0001
Obstructed	-47	33	(-115,20)	0.163	46	22	(2,91)	0.04
Low FVC/Obstru cted	115	38	(37,193)	0.005	111	36	(39,183)	0.003

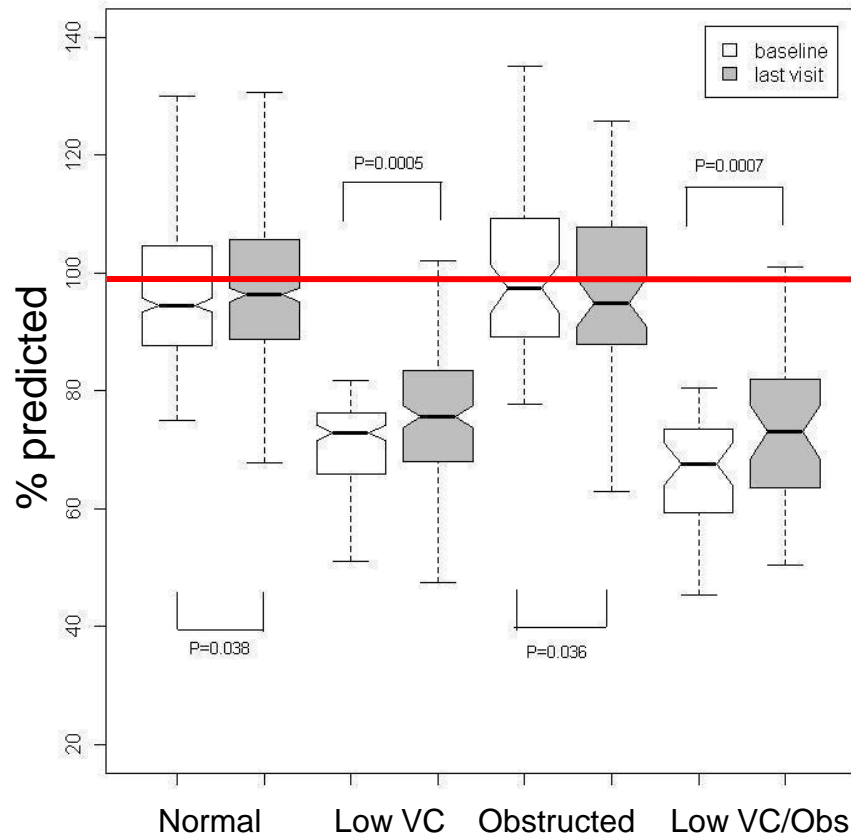
Linear mixed effects model adjusted for age, BMI, gender, race/ethnicity, dust-cloud exposure, smoking status, and WTC exposure category

Liu et al. manuscript submitted

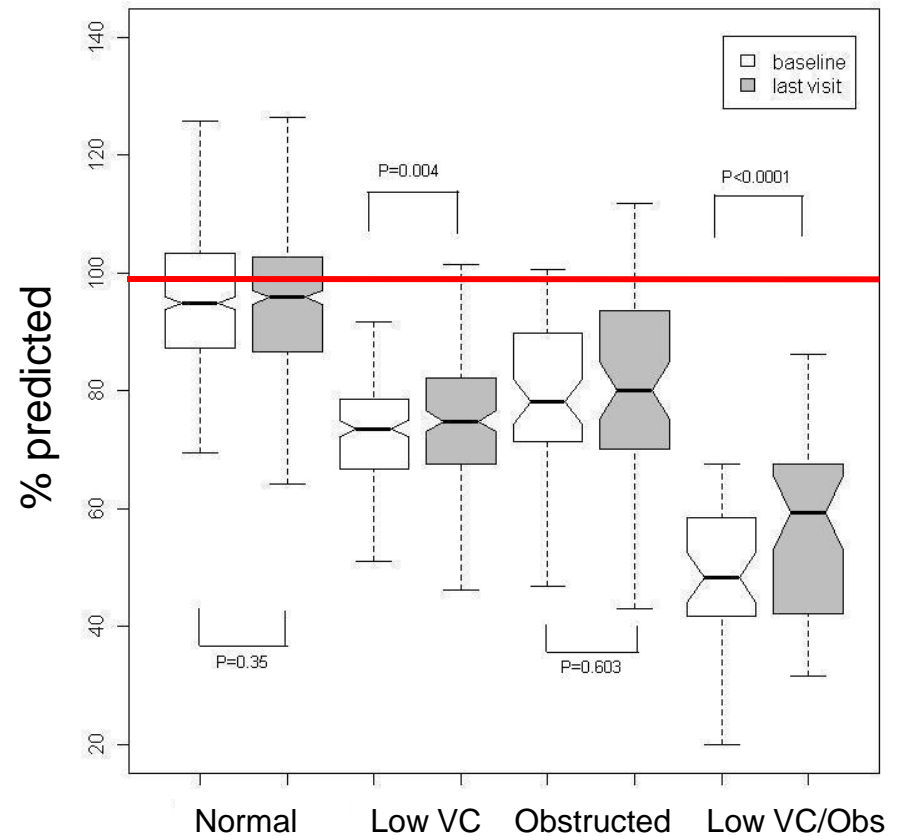
Spirometry in patients in the WTC EHC improved, but did not return to normal if baseline pattern was abnormal

(baseline (white) last visit (grey))

FVC



FEV₁



P-values calculated using Wilcoxon signed rank test for paired data

Liu et al. manuscript submitted

Lung function over time in community members enrolled in WTC EHC by target category (linear annual change ml/year)

	FVC				FEV ₁			
	Estimate ml/year	SE	95% CI	p-value	Estimate ml/year	SE	95% CI	p-value
Total population	54	7	(41,67)	<0.0001	30	5	(19,40)	<0.0001
WTC exposure category								
Resident	53	18	(18,88)	0.003	26	13	(0,51)	0.05
Local worker	20	11	(-2,41)	0.075	7	9	(-10,24)	0.40
Resc/recov	69	10	(50,88)	<0.0001	39	8	(22,55)	<0.0001
Clean-up	114	29	(56,173)	0.0002	61	18	(26,96)	0.001

Linear mixed effects model adjusted for age, BMI, gender, race/ethnicity, dust-cloud exposure, smoking status
Liu et al. manuscript submitted

Risk for probable PTSD in Patients of the WTC EHC enrolled with physical symptoms 4-7 years after 9/11 (n = 1825)

	N	(%) ¹	% PTSD sx within each category	Adjusted OR ³ (95% CI)
Age				
<25	30	(1.6)	33.3	1
25-44	612	(33.5)	41.5	0.91 (0.26-3.19)
45-64	1023	(56.1)	45.0	1.11 (0.32-3.85)
65+	160	(8.8)	28.8	0.68 (0.18-2.52)
Gender				
Male	954	(52.3)	40.4	1
Female	871	(47.7)	44.2	1.37 (1.00-1.87)
Race/Ethnicity				
NH White	577	(31.6)	35.9	1
NH Black	310	(17.0)	34.2	0.6 (0.38-0.92)
Hispanic	725	(39.7)	51.3	1.23 (0.83-1.83)
Asian	174	(9.5)	37.9	0.53 (0.26-1.08)
Income				
≤ 15K/year	775	(42.5)	53.8	2.97 (2.06-4.28)
>15 – 30K/year	327	(17.9)	43.4	1.90 (1.24-2.91)
>30K/year	684	(37.5)	28.4	1

Probable PTSD in Patients of the WTC EHC enrolled with physical symptoms 4-7 years after 9/11 (n = 1825)

	N	(%) ¹	% PTSD sx within each category	Adjusted OR ³ (95% CI)
Exposure Category				
Local worker	782	(42.9)	38.2	1
Clean-up worker	440	(24.1)	54.8	0.74 (0.42-1.3)
Resident	364	(20.0)	37.6	0.81 (0.53-1.23)
Rescue/recovery	184	(10.1)	41.3	1.45 (0.86-2.45)
Other	55	(3.0)	30.9	0.71 (0.32-1.58)
Dust cloud				
No	981	(54.7)	38.1	1
Yes	813	(45.3)	46.7	2.12 (1.54-2.93)
Respiratory symptoms				
Upper and lower	423	(26.8)	56.7	2.81 (1.8-4.38)
Lower only	659	(41.7)	41.3	1.45 (0.96-2.19)
Upper only	155	(7.7)	38.8	1.71 (0.94-3.1)
Neither	378	(23.9)	25.4	1
Dyspnea score				
>3	245	(20.5)	58.8	2.39 (1.64-3.49)
≤3	949	(79.5)	31.4	1
Spirometry category				
Normal	1054	(69.5)	41.2	1
Abnormal	462	(30.5)	42.6	0.87 (0.62-1.22)

Preliminary data on children ≤ 18 on 9/11

Demographic characteristics (n = 87*)

Characteristic	
Sex, %	
Female	55.0
Male	45.0
Age on 9/11 (range)	11 (0-18)
Race/Ethnicity, %	
White	53.2
Black	13.1
Hispanic	23.9
Asian	9.8

Children included if ≤ 18 on 9/11 (n = 156) and had complete data set (n = 87)

Trasande and Fiorino et al. manuscript in preparation

Exposure characteristics of children in the WTC EHC

Exposure characteristics	
Caught in dust cloud, %	38.5
Heavy volume of dust in clothing, hair, %	22.5
Dust in home, %	36.7
Heavy dust in home, %	18.6
School in Southern Manhattan, %	61.4

Presence in dust cloud and risk for abnormal lung function in children

New asthma diagnosis in 22.6%, mean latency of 3.2 years

	OR	P value
FEV ₁ < LLN	2.5	ns
FVC < LLN	3.9	ns
FEV ₁ /FVC < LLN	5.6	0.02
FEF 25-75 < LLN	3.3	0.09
Obstructive pattern	8.8	0.009

LLN = lower limit of normal
Data adjusted for BMI category

Unanswered questions in the “survivor” population

- Medical questions
 - Cancer risk
 - Lung disease – long term progression, types, how to treat
 - Connective tissue disorders
 - Neurologic sequela – headaches, neuropathy
 - Vulnerable populations
- Mental health
 - who is at risk for persistent PTSD
 - long term outcomes
 - treatment of PTSD in civilian populations and associated with complex mental health and physical co-morbid conditions and socioeconomic issues
 - risk for cognitive defects with intractable PTSD

Unanswered questions in the “survivor” population

- Children
 - Medical
 - What are their lung risks
 - Are there developmental/endocrinologic risks
 - Mental health

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Network
9/11 Environmental
Action
Battery Park Residents
Coalition
Independence Plaza
Tenants Org
Southbridge Tenants Org

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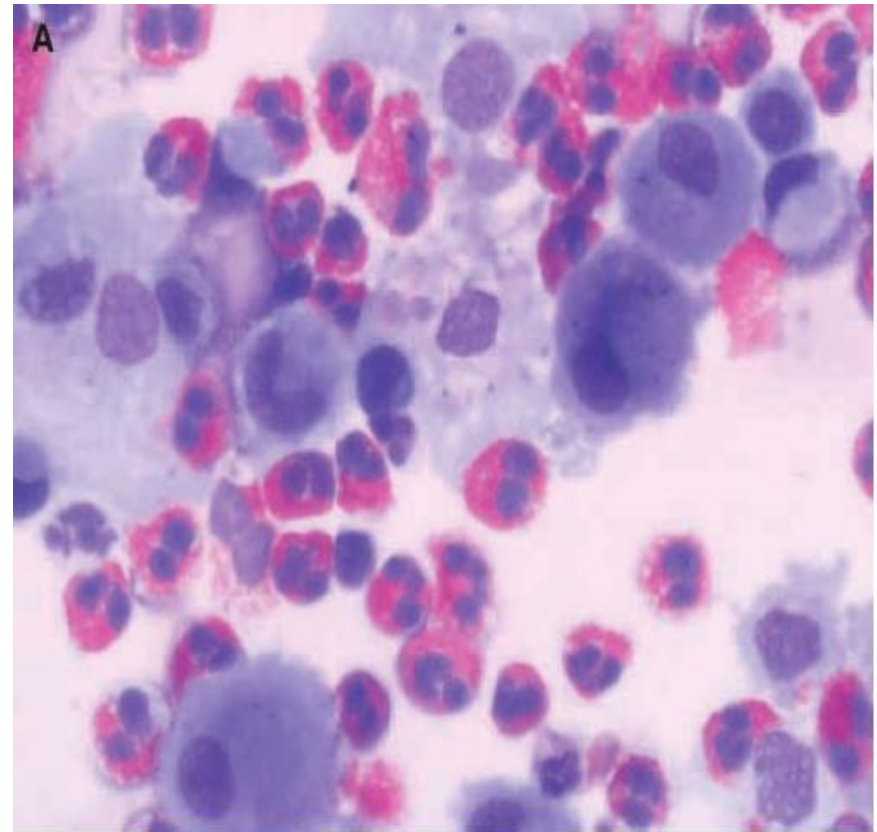
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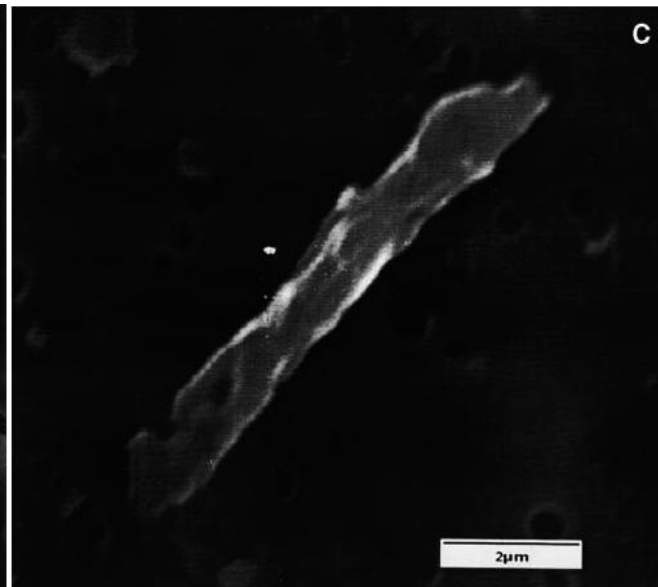
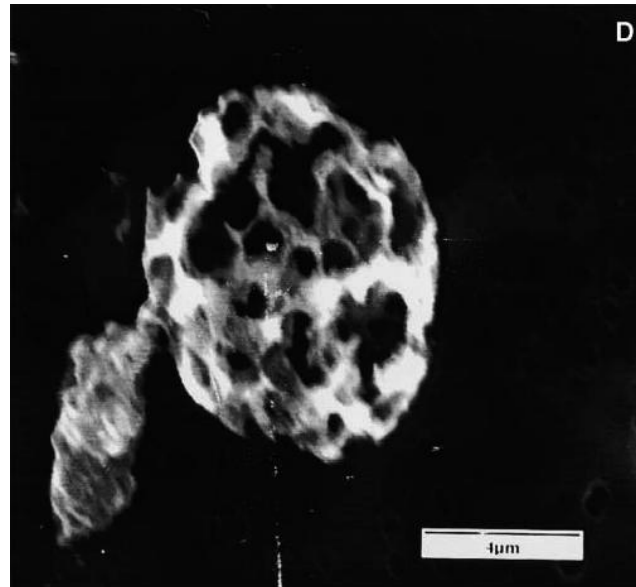
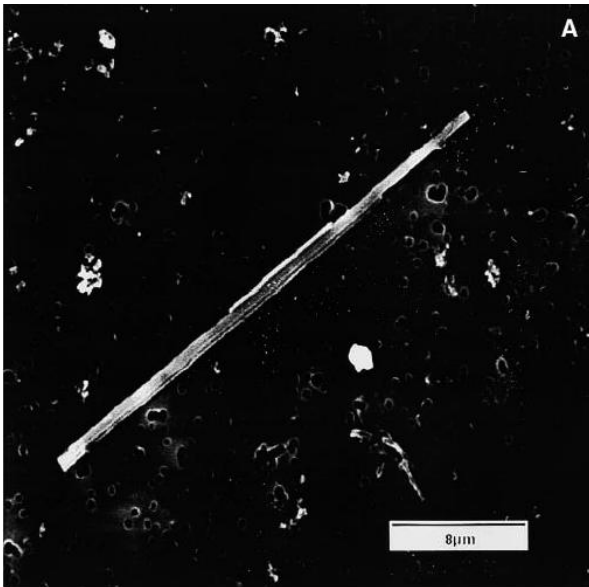
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Early onset disease: Acute eosinophilic pneumonia in a firefighter



Mineralogic analysis of bronchoalveolar lavage from firefighter



(A) Amosite asbestos fiber (uncoated)

(B) Fly ash particle

(C) Degraded fibrous glass.